ARTS ET MÉTIERS ParisTech
Metz

2017/2018 Academic year

Session 2017-1

Final Exam - 1 hour

GTL

Module S43b

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Number of pages and exercises:	3 independent exercises
Allowed materials:	Personal notes Course materials Calculator Dictionary
Instructions:	Do not hesitate to explain or justify your choices! Good luck and good work!

1. Constraint Satisfaction Problem:

The eight queens puzzle is the problem of placing eight chess queens on an 8×8 chessboard so that no two queens threaten each other. Thus, a solution requires that no two queens share the same row, column, or diagonal. The eight queens puzzle is an example of the more general *n*-queens problem of placing n non-attacking queens on an *n*×*n* chessboard, for which solutions exist for all natural numbers *n* (with the exception of n=2 and n=3).

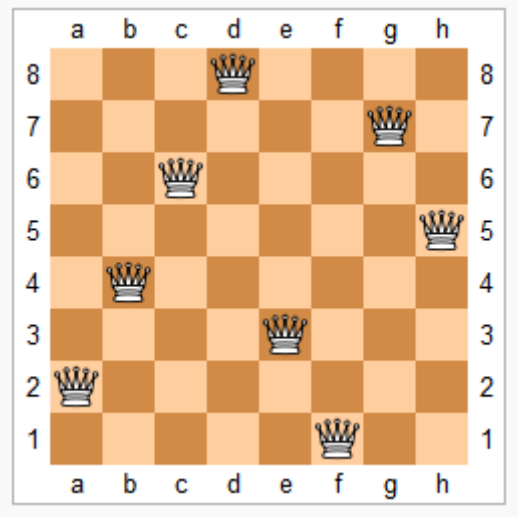


Figure 1 : One solution of the 8-queens problem

Question 1.1: Perform the mathematical modeling (as defined by Montanari) of this Constraint Satisfaction Problem: What are the variables in this problem? What are the domains of each variable?

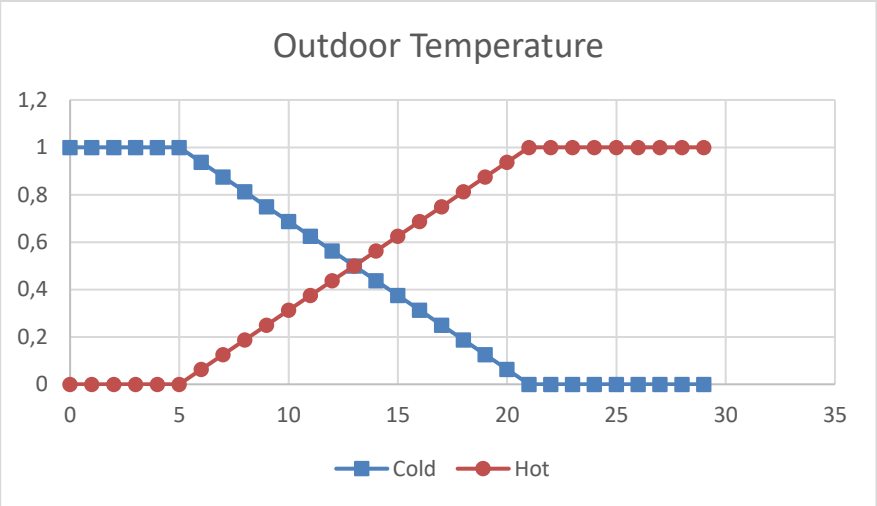
Question 1.2: Detail mathematically the relationships and constraints linking the variables identified and modelled in the previous question.

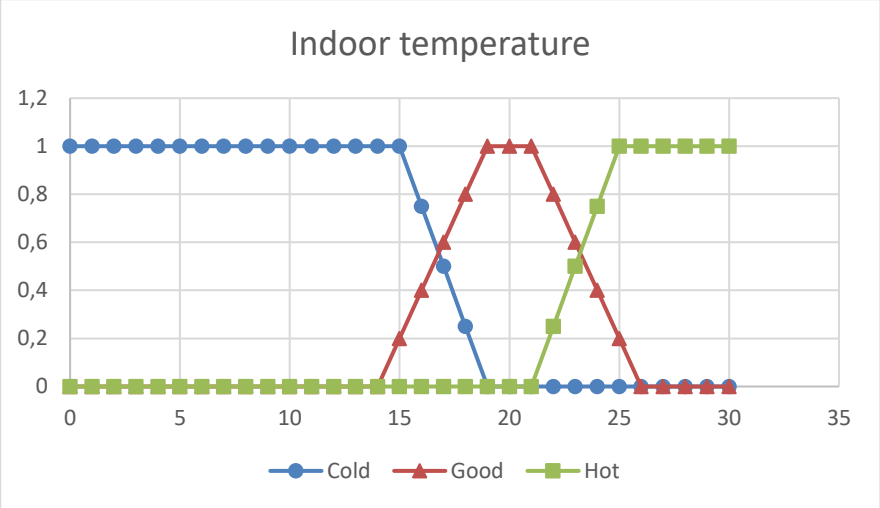
Question 1.3: Detail and justify the 8 first steps of backtracking algorithm applied to this problem when queen#2 is placed in g2, queen#4 on 4h and queen#7 on 7f. Represent this solution exploration in the tree representation as the one we performed during the lecture. For the selection of the value to consider for the variable assignment, you can select the first available in the domain.

2. Fuzzy Logic:

We want to control the heating system of ENSAM school thanks to 2 temperature probes and one fuzzy logic controller. The behavior of the fuzzy controller is based on the following parameter definitions:

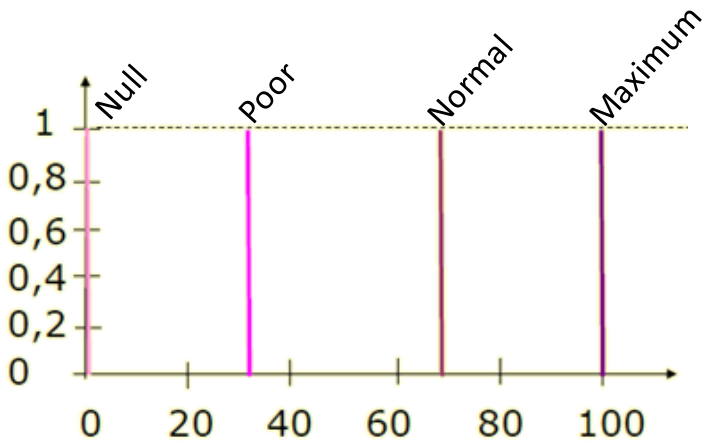
- Input parameters, *Outdoor temperature* and *Indoor temperature*, are described with the following definitions:





- To handle the output parameter (*Heating Power*), a simple model to de-fuzzy is selected. This one is based one single values: the membership value is equal to 0 in the whole domain but in only one point its value is equal to 1:
  - *Null*, for a heating power of 0%
  - *Poor*, for a heating power of 33%
  - *Normal*, for a heating power of 67%
  - *Maximum*, for a heating power of 100%

  In a more graphical way, this output parameter looks like:



- We use the fuzzy operators defined by Mamdami (AND, OR…)
- The aggregator operator is: **Sum**
- The fuzzy laws are defined in the table above:

R1	**IF** Outdoor T° is Cold AND Indoor T° is Cold **THEN** Power is Maximum
R2	**IF** Outdoor T° is Cold AND Indoor T° is Good **THEN** Power is Normal
R3	**IF** Outdoor T° is Cold AND Indoor T° is Hot **THEN** Power is Poor
R4	**IF** Outdoor T° is Hot AND Indoor T° is Cold **THEN** Power is Normal
R5	**IF** Outdoor T° is Hot AND Indoor T° is Good **THEN** Power is Poor
R6	**IF** Outdoor T° is Hot AND Indoor T° is Hot **THEN** Power is Null

Figure 2 : Fuzzy rules to consider in this exercise

Question 2.1: In the case: **Indoor T°= 23°C and Outdoor T°= 13°C**, identify what are the memberships of the input parameters. After triggering the fuzzy rules, synthetize their results and define the shape of the output parameter *Heating Power*.

Question 2.2: By using the de-Fuzzycation operator "Center of Gravity", calculate the complete *Heating Power*.

3. Expert Systems:

An expert system (an order 0 one) has the following rules:

R1	IF A THEN B AND C
R2	IF C THEN E
R3	IF M THEN C
R4	IF I AND K THEN A
R5	IF M AND L THEN A
R6	IF I AND B THEN D
R7	IF E AND (D OR L) THEN F
R8	IF K AND F THEN H

Figure 3: Rules base

The selection step of the expert system follows these meta-rules:

- P1: Priority to the rule having the most numerous conclusions,
- P2: If the first criterion is not enough, priority to the rule having the most numerous conditions
- P3: If the two first criteria are not enough; the priority is given regarding the order of the rule in the rule base (the number in the first column in Figure 3)

The initial fact base is composed by the three facts **{I, L, M}**.

Question 3.1: By using the forward chaining in this priority strategy, detail all steps followed by the expert system from the initial fact base (and detail the facts base for each step) until it stops.

Question 3.2: By using backward chaining, detail the complete AND/OR tree leading to the fact **F**. Is it this fact achievable with the initial fact proposed above?